

TECHNICAL NOTE

A DIRECT FLUID DELIVERY SYSTEM FOR THE PIGEON¹

Woodruff and Williams (1976) outlined a technique for introducing water directly into the mouth of a pigeon. Such direct water delivery bypasses the approach and contact behaviors normally required for the consumption of water. Nonetheless, approach to and contact of a keylight paired with direct water delivery readily emerge as prominent autoshaped responses even though such directed behaviors are not components of the unconditioned response to water delivery (cf. Peterson, Ackil, Frommer, & Hearst, 1972; Wasserman, 1973).

We have developed several modifications of the Woodruff-Williams technique that extend the longevity of the preparation, minimize the amount of exposed tubing, and eliminate the jacket and crossbar assembly used to support the connection to the water pump. The cannula can be constructed from readily available tubing, parts of a 1-cc disposable syringe, and a hypodermic needle. When complete, the preparation is easily connected to a water pump via the Luer-slip connection between the syringe tip and the needle hub. Animals prepared in this manner recover from surgery within 2 to 3 days and show little impairment in feeding or drinking.

MATERIALS

Prior to surgery, the following materials are assembled: a 15-cm section of Intramedic PE 50 polyethylene tubing (i.d. = .58 mm, o.d. = .97 mm), a 4-cm section of Silastic tubing (i.d. = 1.02 mm, o.d. = 2.16 mm), and a small gauge hypodermic needle with a Luer-slip hub.

After warming over the tip of a soldering iron, the PE 50 tubing is bent at a point about 1 cm from one end to form a U-shape about 4 mm wide (inside measurement—see Figure 1). The Silastic tubing is washed and set aside. The external shaft of the hypodermic needle is broken away and a 1-mm diameter hole is drilled through the hub along the needle shaft to form the female connector for the tubing assembly. While almost any small gauge hypodermic needle is adequate, it is advantageous if the length of the hub does not exceed 1.5 cm.

SURGICAL PROCEDURE

Following pretreatment with atrophine sulphate (.08 mg/kg) to minimize respiratory complications, the pigeon is anesthetized with Equithesin (2.25 cc/kg). (We have also used chloral hydrate, 400 mg/kg, successfully without pretreatment.) All injections are made intramuscularly into the pectorals. Intraperitoneal injections have proven less satisfactory and may result

in an extended reduction in feeding, especially with chloral hydrate. A light level of anesthesia is sufficient. Wing movement is prevented by restraint in a sock or towel. We administer Xylocaine subcutaneously in the areas of incision when anesthesia is light.

A hole 1-mm in diameter is drilled through the upper beak at its midline, 1 cm from the tip. The U-shaped end of the PE 50 tubing is inserted through this opening, positioned flush with the palatal plate with the open end directed caudally, and trimmed to a length of 4 mm. A small amount of epoxy is applied around the tubing on the dorsal surface of the beak to secure the tubing in place. Care should be taken that the end of the tubing does not slip into the palatal cleft while the epoxy is setting.

Feathers are removed along the midline around the base of the skull and immediately above the cere, and these areas are cleansed. A small incision is made 5 mm above the cere, and a small probe is inserted and extended just below the skin to clear the initial path for the tubing. The free end of the PE 50 tubing is inserted along this path and carefully guided along the midline to a point along the nape of the neck, 1 cm below the base of the skull. A small incision is made at this point and the tube is pulled through taking care that the point of exit is on the midline. Exit points lateral to the midline will encourage a lateral postoperative displacement of the entire tubing.

The section of Silastic tubing is slid over the end of the PE 50 tubing and into the incision, leaving the end showing. The female connector prepared from the hypodermic hub is then slid over the PE 50 until it rests against the Silastic tubing, and the excess PE 50 is trimmed at the point of exit from the hub. This end is heat flared, and a minute amount of Eastman 910 adhesive is applied to the tubing below the flare. The PE 50 is then pulled back tight into the connector. The end of the Silastic tubing is then advanced to meet the connector and secured in position with epoxy. With the neck extended downward, the incision is closed around the tubing. On completion, from 1.0 to 1.5 cm of tubing lies external to the point of exit. The added strength and resilience of the Silastic tubing prevents breakage of the PE 50 cannula following repeated bending at the point of exit when in use. A

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diagram of the completed assembly is presented in Figure 1.

We routinely administer penicillin (30,000 units, I.M.) postoperatively to minimize the risk of infection. To avoid the accumulation of dust in the cannula, the female connector is sealed with a small rubber plug when not in use. The rubber tip from the plunger of a 1-cc syringe fits this purpose.

FLUID DELIVERY SYSTEM

The male connector that links the pigeon's cannula to the water delivery assembly in the chamber is made from the tip (last 2.0 cm) of a 1-cc disposable syringe secured with epoxy to a section of Intramedic PE 100 polyethylene tubing (i.d. = .86 mm, o.d. = 1.52 mm). The remaining PE 100 tubing is coiled by wrapping it around the shaft of a warm cylindrical iron (e.g., a hair-curling iron). The coil takes up the slack in the tubing as the pigeon moves about. A sufficient length of tubing allows the subject unrestrained movement in the chamber.

The end of the PE 100 tubing is connected to an overhead swivel. We use a locally constructed low-force swivel made from Teflon rod and 19 gauge needle stock.² Details for the construction of an apparently comparable low-force swivel have recently been published (Wirth, Crowder, & Bedford, 1977).

The external connection of the swivel is connected by tubing to a fluid pump. We use Silastic tubing (i.d. = 1.57 mm, o.d. = 3.18 mm) connected to an Ismatec Mini-Micro-2 synchronous motor pump (Brinkman Instruments Inc., Westbury, NY 11590). The amount of water delivery is regulated by the flow rate of the pump and the duration of operation. A flow rate of 2 cc/min with a 4-sec duration of operation (.13 cc/operation) has proven to be an effective reinforcer under typical autoshaping parameters.

MAINTAINING THE PREPARATION

The durability of the assembly is enhanced by the minimal exposure of tubing. However, we have found it practical to reduce the possibility of damage by covering or replacing the wire mesh door in our home cages with a thin sheet of clear Plexiglas. The most common repair involves replacing the U-shaped end of PE 50 tubing in the oral cavity.

The longevity of this preparation is limited primarily by the continual forward growth of the beak. The addition of the 4-mm extension backward into the oral cavity ensures accurate delivery of water as the assembly moves forward and eliminates the problem of spillage, which may result when the end of the cannula terminates immediately below the point of entrance. However, it is advisable routinely to backset the section of cannula entering the upper beak after 8 to 10 weeks. This repair can be effected with the

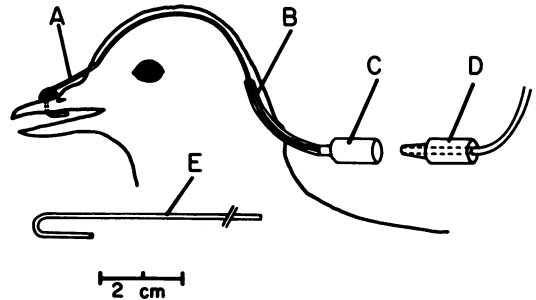


Fig. 1. Diagram of the completed assembly: A—PE 50 cannula; B—Silastic tubing around PE 50 cannula at exit point; C—Luer-slip female connector; D—male connector to water delivery tubing in the chamber; E—shape of the PE 50 tubing before placement.

local administration of Xylocaine to the palate. A new 1-mm hole is drilled 1 cm from the tip of the beak and a new PE 50 cannula is inserted. This segment may be conveniently spliced to the original segment of PE 50 before it enters the forehead by using a 1-cm sleeve of Silastic tubing (i.d. = 1.02 mm, o.d. = 2.16 mm) and Eastman 910 adhesive. Animals recover rapidly and show little decrement in performance on the following day.

RESULTS

We have conducted a number of autoshaping investigations using the chronically implanted cannula with little procedural difficulty. Figure 2 depicts the results of one such investigation that concentrated on the percentage of keylight stimuli followed by water delivery. Four birds were water-deprived to 80% of their free-drinking weights and given 27 to 30 sessions of training, each comprising 40 16-sec illuminations of a pecking key with the time between presentations averaging 60 sec. During the last 6 sec of key illumination, water was injected into the mandibles on 0%, 25%, 50%, or 100% of the trials. Rate of water delivery was 1.8 cc/min (.18 cc/reinforcer). Key contacts to the CS were recorded during the first 10 sec of key illumination.

The first two days of training involved keylight alone presentation (0% reinforcement). As can be seen in Figure 2, none of the four pigeons contacted the illuminated key. In the second stage, pigeons exposed either to 100% reinforcement (Birds 456 and 468) or to 50% reinforcement (Birds 461 and 473) acquired the key-contact response and continued to respond at very high levels for several days. During this phase, subjects approached and contacted the key with drink-like movements; however, individual subjects contacted the key in distinctive ways, resulting in considerable variance in response rates and contact durations. In the final phase, birds were shifted to lower reinforcement percentages. Responding was maintained even when only 25% reinforcement was scheduled.

The low level of responding to the keylight alone under water deprivation in Phase I, plus the absence of directed behaviors during water delivery alone (Woodruff & Williams, 1976), suggests that the cannula preparation is an effective control for generalized re-

²Details for the construction of the Teflon swivel are available from the authors, Department of Psychology, Spence Laboratories of Psychology, University of Iowa, Iowa City, Iowa 52242.

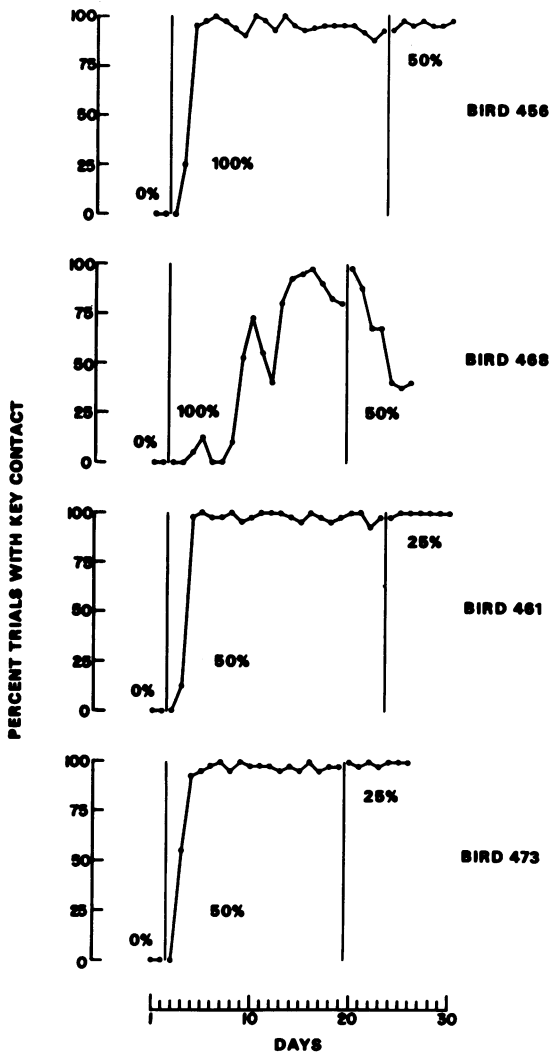


Fig. 2. Percentage of keylight presentations with a key contact response during three phases of training with 0%, 25%, 50%, and 100% direct water reinforcement for four experimentally naive pigeons.

sponding in the autoshaping situation. Although recent reports indicate generalized magazine behaviors may contribute to autoshaping performance (Davol, Steinhauer, & Lee, 1977; Sperling, Perkins, & Duncan, 1977), directed approach and contact behavior is readily acquired and maintained when water is delivered directly into the mandibles, thereby eliminating magazine behaviors from the experimental situation (also see Peterson et al., 1972; Wasserman, 1973).

ALTERNATE PLACEMENT

The procedure described above results in some damage to the sensory branches of the trigeminal system innervating the upper beak. While we have not observed substantial postoperative impairment in feed-

ing with the above procedure, Zeigler (1975a, 1975b) has reported that the interruption of sensory feedback in the trigeminal system may result in extended deficits in feeding behavior, although drinking and keypecking behaviors remain intact. We have recently developed an alternate placement which avoids damage to those fibers by entering the oral cavity through the nasal passage.

Before surgery, the delivery end of the PE 50 tubing is bent in an S-shape (see Figure 3). The subject is anesthetized as above. The PE 50 tubing is held with the delivery end of the S-shape positioned dorsally and inserted through one of the external nares. The tubing is advanced caudally and ventrally through the nasal passage so that the end exits through the palatal cleft. A slight bend at the tip of the tubing facilitates this passage. This end is then pulled forward, toward the tip of the beak, while the curve in the tubing is rotated through the nasal passage. A hollow 17 gauge needle is inserted through the naris and passed through the dorsal surface of the cere near midline. The free end of the PE 50 tubing is passed through the shaft of the needle, and the needle and tubing are pulled through. The tubing is then pulled into position so that the second bend in the tubing is located at the point of exit from the cere. A 3-mm ring of Silastic tubing is slid over the free end of the PE 50 tubing to the cere. The remaining PE 50 tubing is passed beneath the skin over the head and joined to the connector as described above.

When the assembly is completed, the cannula should fit flush with the palatal plate. The end is trimmed so that the point of fluid delivery lies anterior to the palatal cleft. The 3-mm Silastic ring is then positioned against the forehead and secured to the PE 50 tubing with epoxy to prevent the cannula from slipping caudally. A diagram of the modified assembly is shown in Figure 3.

Since this modification does not anchor the cannula

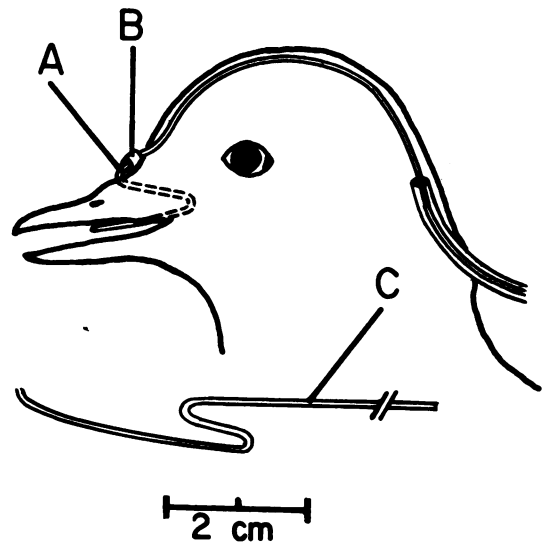


Fig. 3. Diagram of the modified assembly: A—PE 50 cannula; B—3-mm Silastic ring; C—shape of the PE 50 tubing before placement.

in the growing tip of the beak, the placement of the cannula remains fixed as the beak grows forward. This placement therefore may be preferred when the preparation is to remain in use for more than eight weeks. However, since the position of the cannula in this design depends on the shape of the tubing, more care is required at the time of placement to ensure an accurate fit. Slight modifications in the size of the S-shape at the delivery end of the cannula may be necessary for individual animals. When the cannula is implanted directly through beak this problem is rarely encountered. That procedure may therefore be advantageous when many animals are to be used in relatively short-term studies. In either case, it is important that the cannula does not project downward from the palate, a placement that may result in oral lesions.

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